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Arterial Territories of the Human Brain

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Abstract

We present a brain map of the areas supplied by various arteries in the brainstem, cerebellum and cerebral hemispheres. Arterial territories are depicted in a form that is directly applicable to neuroimaging slices in clinical practice. The arterial territories are outlined based on an extensive overview of anatomical studies of cerebral blood supply. For arterial territories of the hemispheres, we present the variability of the cortical territories of the three main cerebral arteries and define the minimal and maximal cortical supply areas.

In this chapter, we present a brain map of the areas supplied by various arteries in the brainstem, cerebellum and cerebral hemispheres. Arterial territories are depicted in a form that is directly applicable to neuroimaging slices in clinical practice. The map is presented on a series of 24 templates, based on a bicommissural plane passing through the center of the anterior and posterior commissures. The sections of the brainstem and cerebellum (sections I–XII) are 4 mm thick, whereas those of the cerebral hemispheres (sections XIII–XXIV) are 8 mm thick. The anatomical structures are shown on the right side of the sections and the arterial territories appear on the left.

Morphological data for the 24 sections are based on anatomical atlases by Duvernoy [1–3]. The arterial territories are outlined based on an extensive overview of anatomical studies of cerebral blood supply. This overview included either vascular injection studies or microanatomic studies of the cerebral arteries, and is developed in more detail elsewhere [4–6]. For arterial territories of the hemispheres, we have chosen to explain in detail the variability of the cortical territories of the three main cerebral arteries and to define the minimal and maximal cortical supply areas with reference to a baseline anatomical study [7].

This chapter is intended to provide a graphical overview of the anatomy of the cerebral arteries. A more detailed approach can be found elsewhere [8].

Arterial Supply of the Brainstem

Arterial trunks supplying the brainstem include the vertebral artery, basilar artery, anterior and posterior spinal arteries, posterior inferior cerebellar artery, anterior inferior cerebellar artery, superior cerebellar artery, posterior cerebral artery, and anterior choroidal artery. The collaterals of these arteries are divided into four

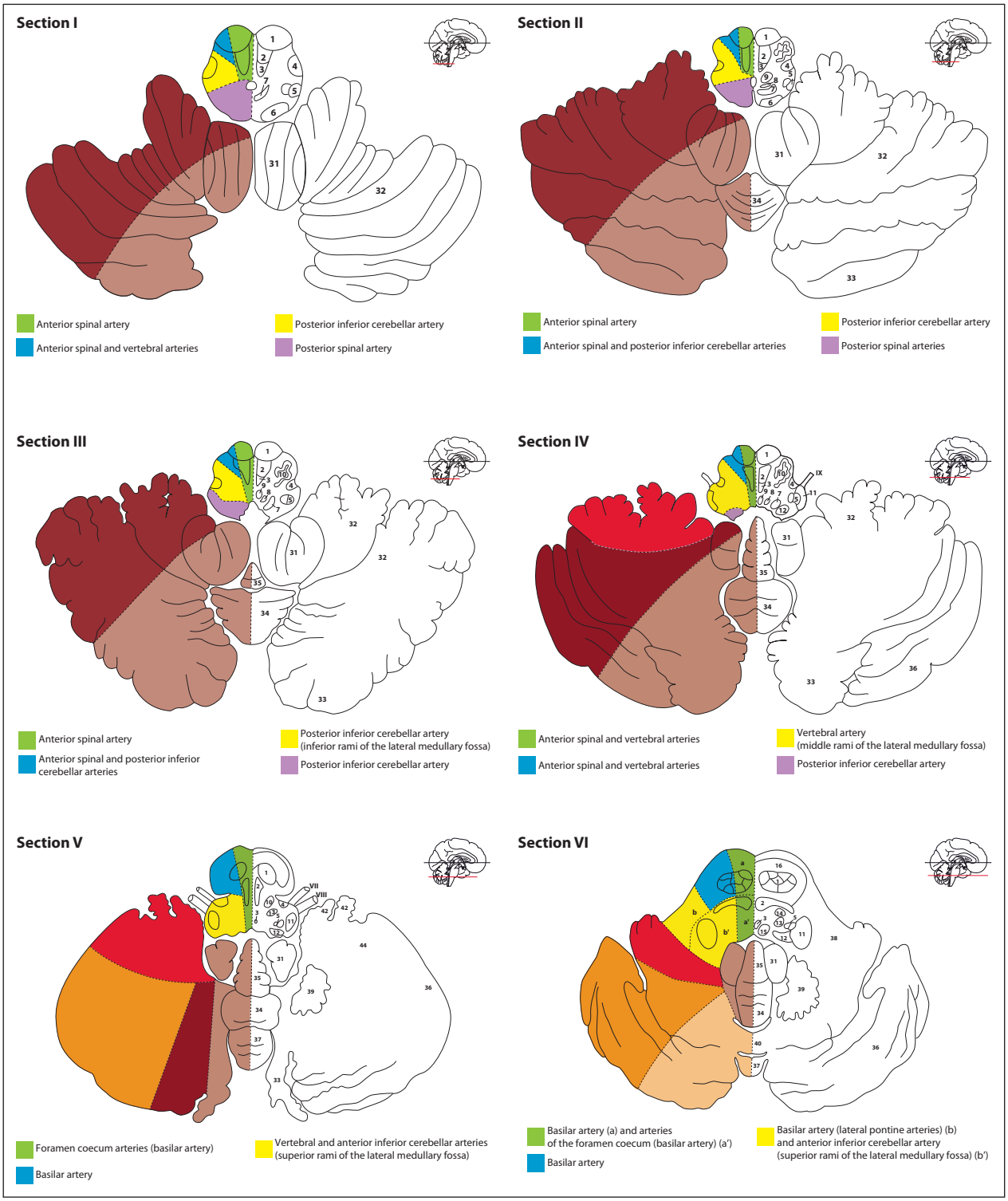


Fig. 1. Sections I–XII: arterial territories mapping: brainstem and cerebellum. For abbreviations and color codes see pp. 105–107.

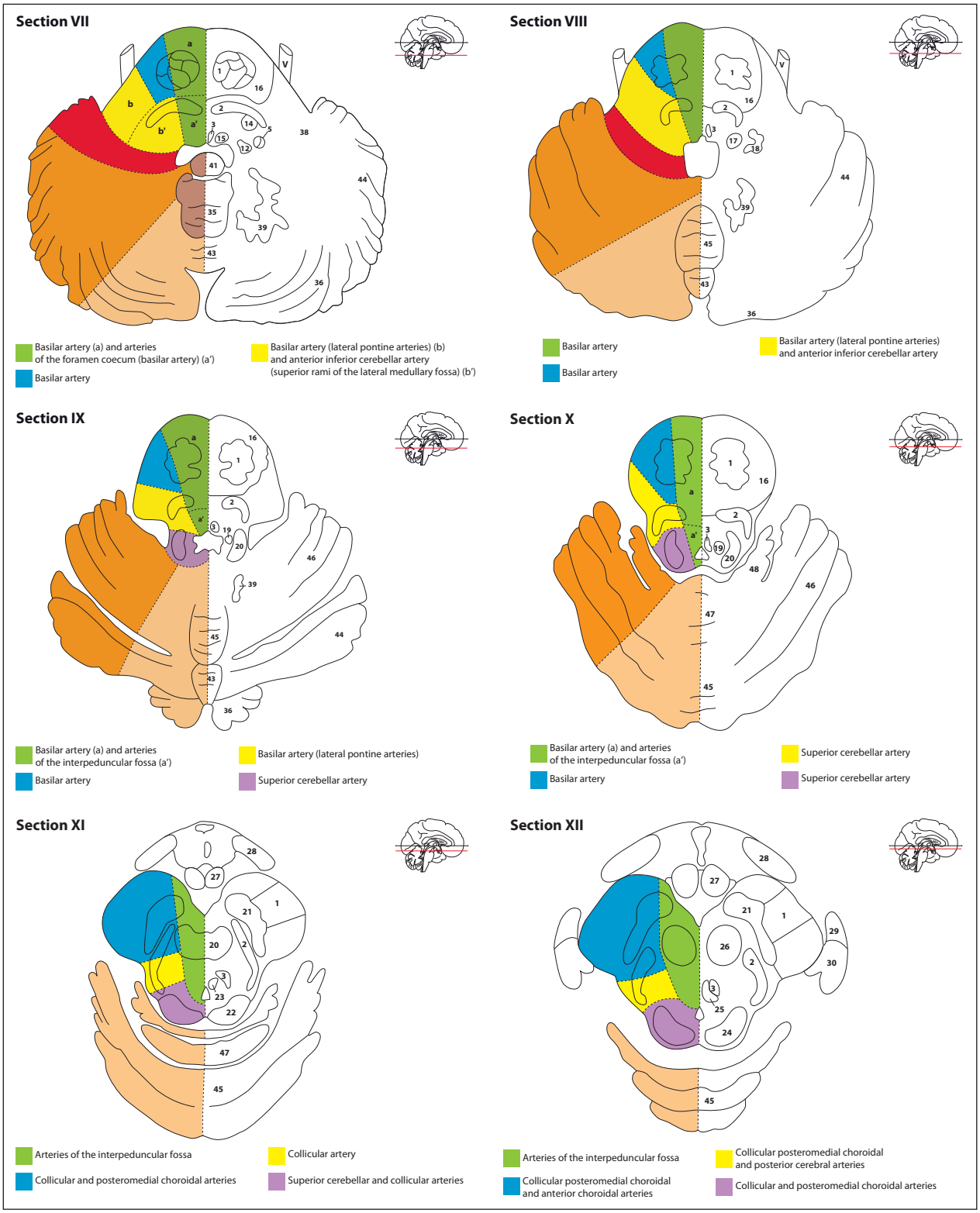


Fig. 1. Continued

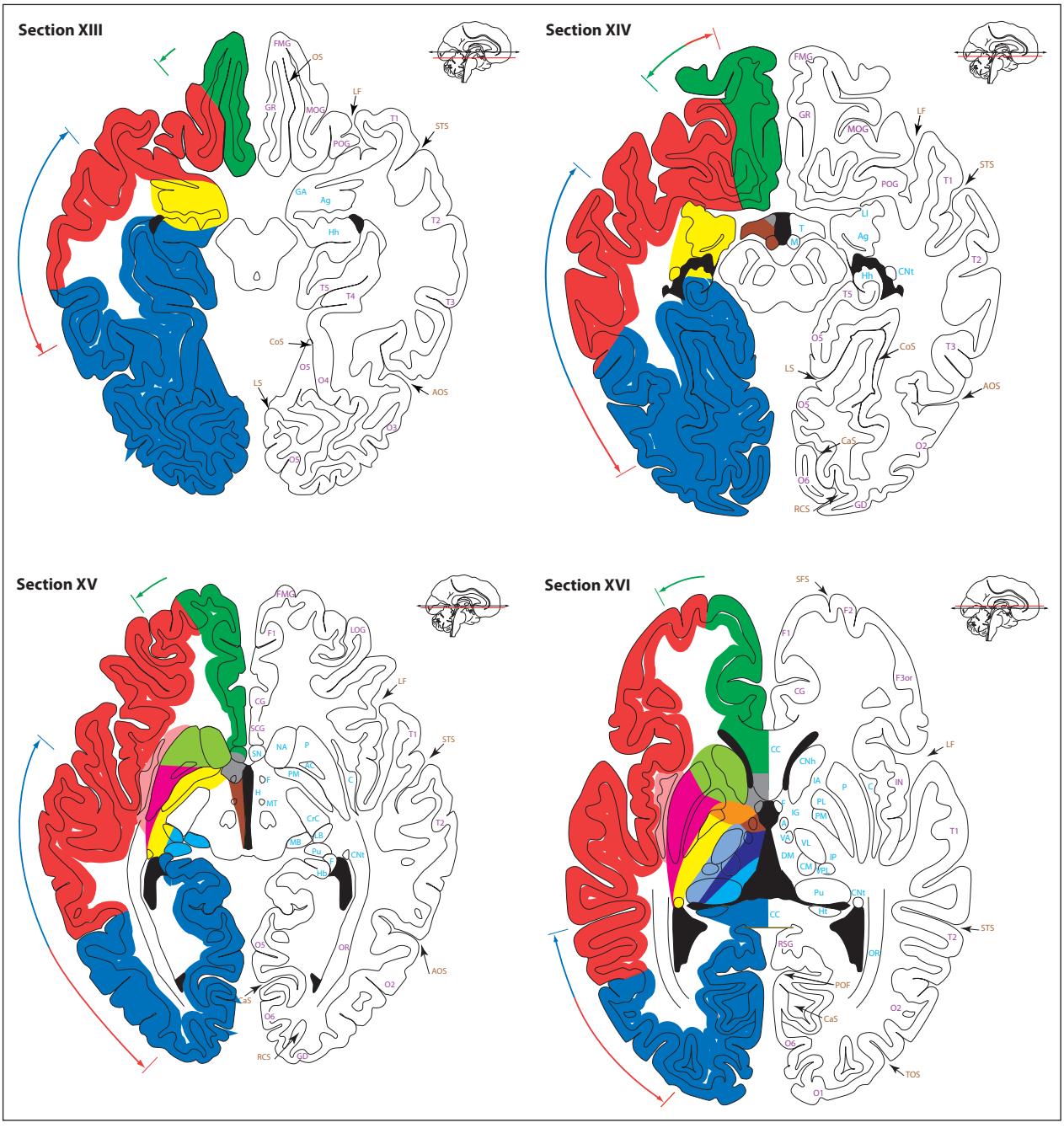


Fig. 2. Sections XIII–XXIV: arterial territories mapping: cerebral hemispheres. For abbreviations and color codes see pp. 105–107.

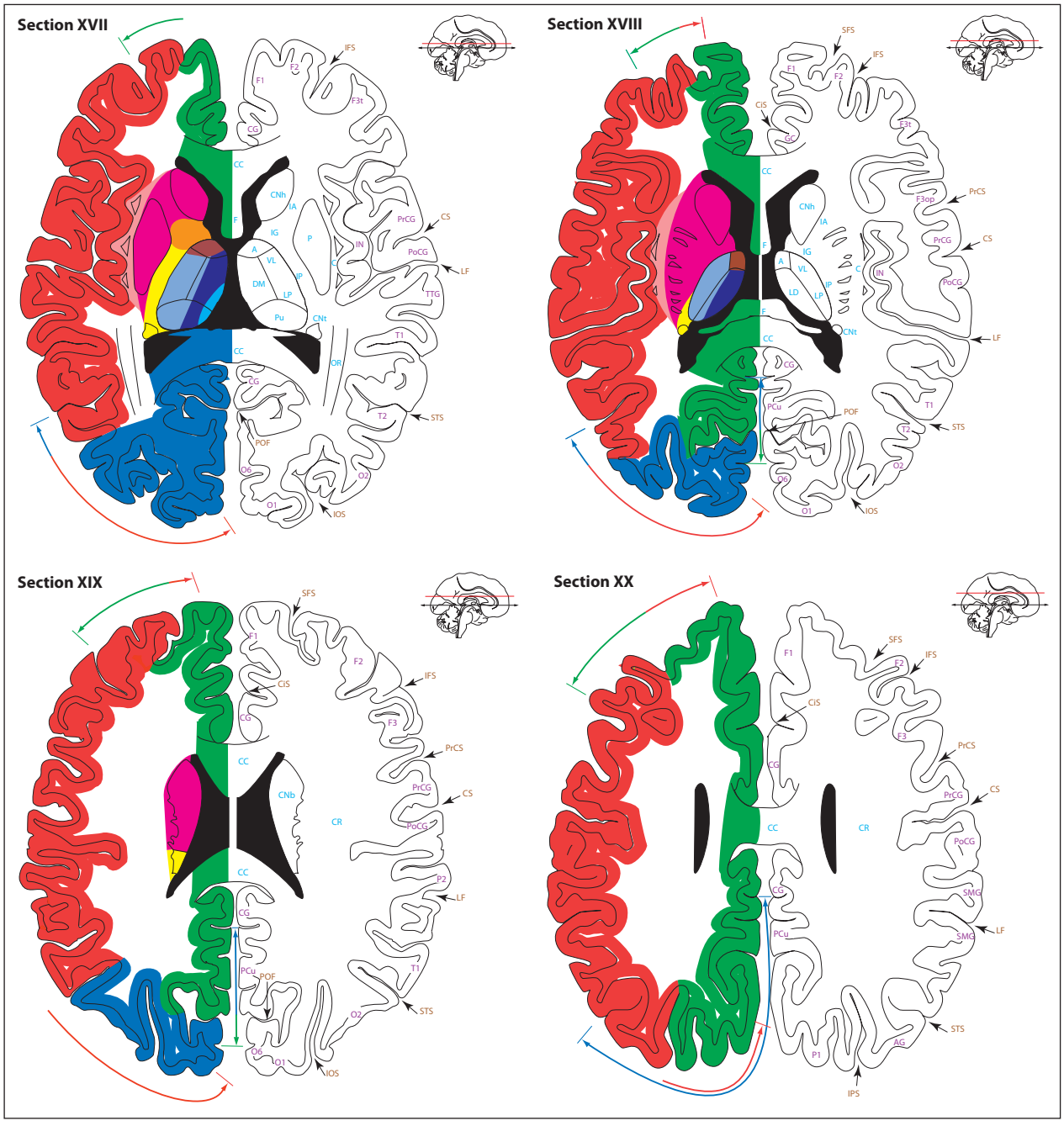


Fig. 2. Continued

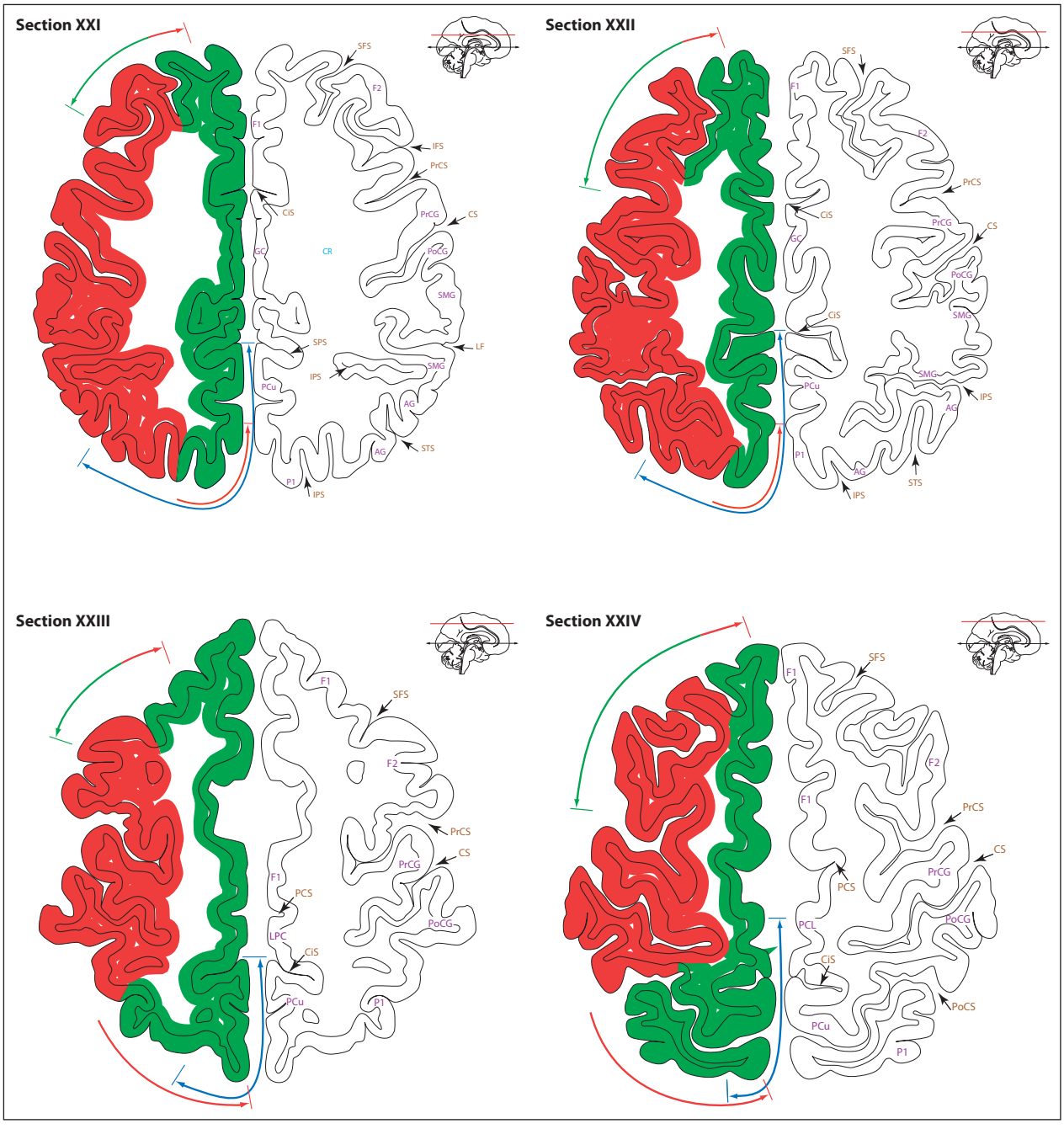


Fig. 2. Continued

Abbreviations: Anatomical structures of the brainstem and the cerebellum (sections I–XII)

1	Corticospinal tract
2	Medial lemniscus
3	Medial longitudinal fasciculus
4	Spinothalamic tract
5	Spinal trigeminal tract and nuclei
6	Gracile and cuneate nuclei
7	Nucleus of the solitary tract
8	Dorsal motor vagal nucleus
9	Hypoglossal nucleus
10	Inferior olivary nucleus
11	Inferior cerebellar peduncle
12	Vestibular nucleus
13	Facial nucleus
14	Superior olivary nucleus
15	Abducens nucleus
16	Pontine nuclei
17	Motor trigeminal nucleus
18	Principal sensory trigeminal nucleus
19	Nucleus coeruleus
20	Superior cerebellar peduncle
21	Sustantia nigra
22	Inferior colliculus
23	Trochlear nucleus
24	Superior colliculus
25	Oculomotor nucleus
26	Red nucleus
27	Mamillary body
28	Optic tract
29	Lateral geniculate body
30	Medial geniculate body
31	Tonsil
32	Biventer lobule
33	Inferior semilunar lobule
34	Pyramid of vermis
35	Uvula
36	Superior semilunar lobule
37	Tuber of vermis
38	Middle cerebellar peduncle
39	Dentate nucleus
40	Folium of vermis
41	Nodulus
42	Flocculus
43	Declive
44	Simple lobule
45	Culmen
46	Quadrangular lobule
47	Central lobule
48	Ala of the central lobule
V	Trigeminal nerve
VII	Facial nerve
VIII	Vestibulocochlear nerve
IX	Glossopharyngeal nerve

Abbreviations: Anatomical structures of cerebral hemispheres (sections XIII–XXIV)

Gyri (purple)

CG	Cingulate gyrus
F1	Superior frontal gyrus
F2	Middle frontal gyrus
F3	Inferior frontal gyrus
F3op	Inferior frontal gyrus pars opercularis
F3or	Inferior frontal gyrus pars orbitalis
F3t	Inferior frontal gyrus pars triangularis
FMG	Frontomarginal gyrus
GR	Gyrus rectus
LOG	Lateral orbital gyrus
MOG	Medial orbital gyrus
PCu	Precuneus
POG	Posterior orbital gyrus
SCG	Subcallosal gyrus
IN	Insula
PCL	Paracentral lobule
PoCG	Postcentral gyrus
PrCG	Precentral gyrus
AG	Angular gyrus
P1	Superior parietal gyrus
P2	Inferior parietal gyrus
SMG	Supramarginalis gyrus
T1	Superior temporal gyrus

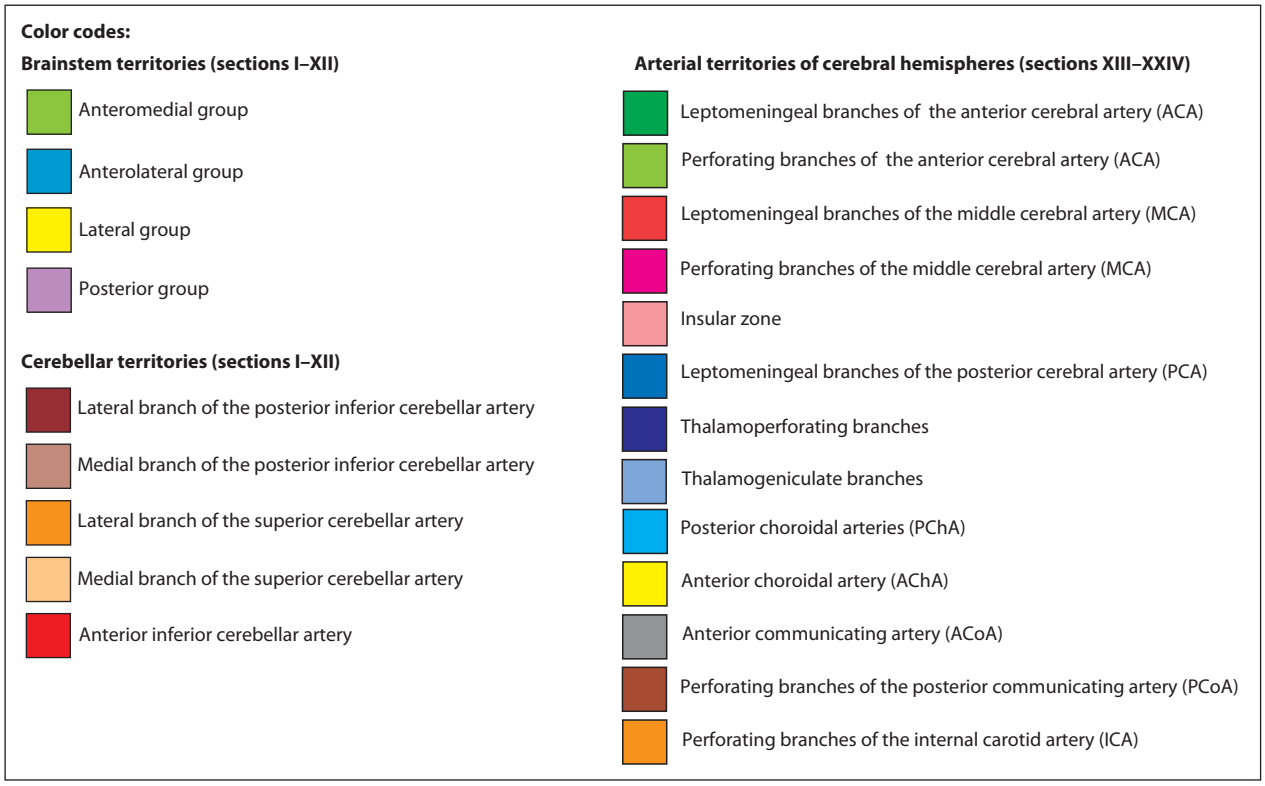
T2	Middle temporal gyrus
T3	Inferior temporal gyrus
T4	Fusiform gyrus
T5	Parahippocampal gyrus
TTG	Transverse temporal gyrus
O1	Superior occipital gyrus
O2	Middle occipital gyrus
O3	Inferior occipital gyrus
O4	Fusiform gyrus
O5	Lingual gyrus
O6	Cuneus
GD	Gyrus descendens (Ecker)
RSG	Retrosplenial gyrus

Sulci (brown)

AOS	Anterior occipital sulcus
CaS	Calcarine sulcus
CiS	Cingulate sulcus
CoS	Collateral sulcus
CS	Central sulcus
IFS	Inferior frontal sulcus
IOS	Intra-occipital sulcus
IPS	Intraparietal sulcus
LF	Lateral fissure
LS	Lingual sulcus
OS	Olfactory sulcus
PCS	Paracentral sulcus
PoCS	Postcentral sulcus
POF	Parieto-occipital fissure
PrCS	Precentral sulcus
RCS	Retrocalcarine sulcus
SFS	Superior frontal sulcus
SPS	Subparietal sulcus
STS	Superior temporal sulcus (parallel sulcus)
TOS	Transverse occipital sulcus

Internal structures (blue)

CNb	Caudate nucleus, body
CNh	Caudate nucleus, head
CNt	Caudate nucleus, tail
IA	Internal capsule, anterior limb
IG	Internal capsule, genu
IP	Internal capsule, posterior limb
NA	Nucleus accumbens
P	Putamen
PL	Globus pallidus, pars lateralis
PM	Globus pallidus, pars medialis
SN	Septal nuclei
A	Anterior thalamic nucleus
CM	Centromedian thalamic nucleus
DM	Dorsomedial thalamic nucleus
LD	Lateral dorsal thalamic nucleus
LP	Lateral posterior thalamic nucleus
Pu	Pulvinar
VA	Ventral anterior thalamic nucleus
VL	Ventral lateral thalamic nucleus
VPL	Ventral posterolateral thalamic nucleus
C	Claustrum
CR	Corona radiata
IN	Insula
LI	Limen insulae
CC	Corpus callosum
F	Fornix
Hb	Hippocampus, body
Hh	Hippocampus, head
Ht	Hippocampus, tail
AC	Anterior commissure
Ag	Amygdala
CrC	Crus cerebri
GA	Gyrus ambiens
H	Hypothalamus
LB	Lateral geniculate body
M	Mamillary body
MB	Medial geniculate body
MT	Mamillo-thalamic tract
OR	Optic radiations
T	Tuber



arterial groups (anteromedial, anterolateral, lateral and posterior) according to their point of penetration into the parenchyma. Each of these groups supplies the corresponding arterial territories in the brainstem. The arterial territories have a variable extension at different levels of the brainstem.

Arterial Groups Supplying the Medulla

The medulla is supplied by the vertebral arteries and the posterior inferior cerebellar artery, which give rise to the rami of the lateral medullary fossa, and by the anterior and posterior spinal arteries.

Arterial Groups Supplying the Pons

Different arterial trunks supply blood to the pons including the vertebral artery, the anterior inferior cerebellar artery, from which arise the rami of the lateral medullary fossa, the superior cerebellar artery and the basilar artery. The anteromedial pontine territory is supplied by distinct arterial sources arising from different levels of the basilar artery. These sources include foramen caecum arteries, pontine arteries and inferior rami arising from the interpeduncular fossa arteries. This point is crucial to understanding the clinical signs of alternate pontine infarction syndromes. The posterior territory only exists in the upper part of the pons.

Arterial Groups Supplying the Midbrain

Five arterial trunks supply the midbrain: the superior cerebellar artery (mainly the medial branch), the collicular artery, the posteromedial choroidal artery, the middle rami of the interpeduncular arteries arising from the posterior cerebral artery

and the anterior choroidal artery arising from the carotid system.

Arterial Supply of the Cerebellum

The cerebellum is supplied by the three long cerebellar arteries: posterior inferior cerebellar artery, anterior inferior cerebellar artery and superior cerebellar artery.

The posterior inferior cerebellar artery originates from the vertebral artery. It gives off medial and lateral branches and supplies the inferior vermis as well as the inferior and posterior surfaces of the cerebellar hemispheres. The posterior inferior cerebellar artery also forms part of the lateral and posterior groups of the medulla, either via its common stem or its medial branch.

The anterior inferior cerebellar artery usually arises from the bottom third of the basilar artery and supplies the anterior surface of the simple, superior and inferior semilunar lobules as well as the flocculus. In most cases, it gives rise to the internal auditory artery. The anterior inferior cerebellar artery contributes to the supply of the middle cerebellar peduncle and often the lower part of the pontine tegmentum.

The superior cerebellar artery – also known as the anterior superior cerebellar artery – divides into medial and lateral branches and supplies the superior half of the cerebellar hemisphere and vermis as well as the dentate nucleus. The superior cerebellar artery territory often includes the upper part of the pontine tegmentum.

Arterial Supply of Cerebral Hemispheres

The cerebral arteries are divided into perforating and cortical arteries. The perforating arteries (or deep perforating arteries) arise from the arterial circle of Willis or from its immediate branches and directly penetrate the brain parenchyma. The internal carotid artery, anterior choroidal artery, anterior communicating artery, anterior cerebral artery, middle cerebral artery, posterior communicating artery and posterior cerebral artery all give rise to perforating arteries.

The cortical arteries (also known as leptomeningeal, superficial or pial) consist of the terminal branches of the anterior, middle and posterior cerebral arteries, which form an anastomotic network on the surface of the hemispheres. Their branches penetrate the cortex, subjacent white matter and U-fibers. The deepest of these branches form the medullary (or superficial perforating) arteries and participate in centrum ovale vascularization.

Several points relating to the arterial circulation of the cerebral hemispheres still need to be elucidated including the vascular organization of the centrum ovale or the peri-insular region.

Perforating Branches of the Cerebral Arteries

Perforating Branches of the Internal Carotid Artery

Some perforating arteries arise from the supraclinoid portion of the internal carotid artery, pass through the anterior perforated substance to supply the genu of the internal capsule, the adjacent part of the globus pallidus and the contiguous posterior limb of the internal capsule.

Perforating Branches of the Anterior Choroidal Artery

The perforating territory of this artery, arising from the supraclinoid portion of the internal carotid artery, includes the lower part of the two posterior thirds and the retrolenticular part of the internal capsule, the adjacent optic radiations and acoustic radiations, the medial globus pallidus and the tail of the caudate nucleus.

Perforating Branches of the Anterior Communicating Artery

The vascular territory of this artery includes the lamina terminalis, the anterior hypothalamus,

the septum pellucidum, part of the anterior commissure and of the fornix, the paraterminal gyrus including the septal nuclei and occasionally the subcallosal region, the anterior part of the corpus callosum and the cingulate gyrus.

Perforating Branches of the Anterior Cerebral Artery

The direct perforators of the anterior cerebral artery usually arise from the proximal pre-communicating segment, and the recurrent artery of Heubner from the proximal post-communicating segment. These arteries supply the anterior and inferior part of the head of the caudate nucleus, the anterior and inferior portions of the anterior limb of the internal capsule, the adjacent part of the putamen and globus pallidus, the caudal rectus gyrus, the subcallosal gyrus and the medial part of the anterior commissure.

Perforating Arteries of the Middle Cerebral Artery

These are the lenticulostriate arteries arising from the basal segment of the middle cerebral artery. They are usually classified into two groups: the medial and the lateral arteries. These perforating branches supply the superior part of the head and the body of the caudate nucleus, the lateral segment of the globus pallidus, the putamen, the dorsal half of the internal capsule and the lateral half of the anterior commissure.

Perforating Branches of the Posterior Communicating Artery

Some branches arise from the posterior communicating artery. The largest branch is termed the premamillary artery (anterior thalamoperforating artery or tuberothalamic artery). These branches supply the posterior portion of the optic chiasm and optic tract, the posterior part of the hypothalamus, the mamillary body, the nucleus anterior and the polar part of the nucleus ventralis anterior of the thalamus.

Thalamoperforating Branches

The thalamoperforating arteries (or paramedian thalamic arteries) form the superior rami of the interpeduncular arteries and contribute to the supply of the thalamus. They supply the medial nuclei, the intralaminar nuclei, part of the dorsomedial nucleus, the posteromedial portion of the lateral nuclei and the ventromedial pulvinar.

Thalamogeniculate Branches

The thalamogeniculate arteries (or inferolateral thalamic arteries) usually arise from the posterior cerebral artery segment in proximity to the geniculate bodies and take part in the surrounding arterial anastomotic network. They supply a major part of the lateral side of the caudal thalamus including the rostrolateral part of the pulvinar, the posterior part of the lateral nuclei and lateral dorsal nucleus, and the ventral posterior and ventral lateral nuclei.

Perforating Branches of the Posterior Choroidal Arteries

The posterior choroidal group usually arises from perimesencephalic segments of the posterior cerebral artery and includes one medial and several lateral posterior choroidal arteries. The medial posterior choroidal artery supplies the medial geniculate body, as well as the posterior part of the medial nucleus and of the pulvinar. The lateral posterior choroidal artery supplies part of the lateral geniculate body, part of the thalamic dorsomedial nucleus and part of the pulvinar.

Cortical Branches of the Cerebral Arteries

Cortical Branches of the Anterior Cerebral Artery

These branches arise from the distal segment of the anterior cerebral artery, also called the pericallosal artery, which gives rise to cortical and callosal branches. The callosal branches supply

the rostrum, genu and body of the corpus callosum. In most cases, the cortical branches supply the cortical area of the medial surface of the hemisphere extending to the superior frontal sulcus and the parieto-occipital sulcus. On the orbitofrontal surface, the arterial territory includes the medial orbital gyri. At most the cortical anterior cerebral artery territory reaches the inferior frontal sulcus and at least, it includes only the anterior part of the frontal lobe.

Cortical Branches of the Middle Cerebral Artery

These cortical branches most commonly distribute to the area on the lateral surface of the hemisphere that extends to the superior frontal sulcus, the intraparietal sulcus and the inferior temporal gyrus. On the orbitofrontal surface, the arterial territory includes the lateral orbital gyri. The maximum area covers the whole lateral surface of the hemisphere, reaching the interhemispheric fissure and the minimum area is confined to the territory between the inferior frontal and the superior temporal sulci.

Cortical Branches of the Posterior Cerebral Artery

These branches include the hippocampal arteries and the splenial artery which anastomose with the distal part of the pericallosal artery to supply the splenium of the corpus callosum. The most common cortical distribution of these arteries includes the inferomedial surfaces of the temporal and the occipital lobes extending to the parieto-occipital fissure. The maximum area can extend as far as the superior temporal sulcus and the upper part of the precentral sulcus, and the minimum area extends only as far as the medial face of the occipital lobe limited by the parieto-occipital fissure.

Cortical Branches of the Anterior Choroidal Artery

The cortical territory of the anterior choroidal artery includes part of the uncus, part of the head of the hippocampus, part of the amygdaloid nucleus and the lateral part of the lateral geniculate body.

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